

ACPC Natural Laboratories Roadmap 2019–2020

Leads: Matt Christensen and Andrew Gettelman

Interested:

Andrew Gettelman, Minghuai Wang, Jiwen Fan, Philip Stier, Johannes Quaas, Matt Christensen, Danny Rosenfeld, Yannian Zhu, Kenta Suzuki, Jan Kazil, Michael Diamond, Rob Wood, Velle Toll, Ed Gryspeerdt, Anna Possner, Tom Goren, Graham Feingold, Ken Carslaw, Daniel Grosvenor, Daniel Partridge, Johannes Mulmenstadt, Adam Povey, Duncan Watson–Parris, Masaru Yoshioka, Florent Malavelle, Dan Partridge, Jim Haywood, Anja Schmidt

Volcanoes and Ship Tracks are two “Natural Laboratories” for examining Aerosol effects on precipitation and climate. This group is designed to facilitate work and add value to existing and planned projects with synergies between groups with different projects.

Overall Summary of Activities (Sub-Groups):

1. Ship emissions (Christensen)
 - a. Shiptrack Emissions Forcing: (ACRUISE) Larger scale. Present and Policy Changes
 - i. Satellite: Gryspeerdt (Imperial),
 - ii. Satellite: Christensen, Watson–Parris, (Oxford) ACRUISE
 - iii. Modeling: Grosvenor (Leeds). ACRUISE
 - iv. Modeling: Gettelman (NCAR/Oxford)
 - b. Regional-scale shipping corridors
 - i. Satellite: Diamond (U. Washington)
 - ii. Modeling: anyone like to participate here? Yes (Anna, Michael)

Results during 2019–2020: Work on individual ships (publications, Gryspeerdt GRL). Development of automated detection methods (Duncan). Shipping lanes: Diamond (paper) + modeling results (unpublished). Work on 2020 potential shipping emissions changes (Leeds, NCAR) + Observations (Gryspeerdt examples). ACRUISE work (not presented but lots of data).

2. Stationary Natural Laboratories Volcanic/Industrial (TBD)
 - a. Aerocom GCM Volcanic ACI experiment (Malavelle)
 - b. Regional Volcanoes: Grosvenor (Holuhraun); Quaas (Holuhraun, Eyjafjallajökull and Pinatubo)

- c. Lagrangian Methods: Kazil, Christensen , Global model analysis (Gettelman), Goren
- d. Develop a common list of locations and emissions magnitudes

Results during 2019–2020: Aerocom GCM Volcanic experiment has 8–10 models. Analysis Continuing. Regional work using different modeling scales (Leipzig: Manhoosh. Used models for emissions). Lagrangian methods (Satellite and Models: Christensen). Stationary source list developed. Volcano work by U. Wuhan (with Rosenfeld).

- 3. Analysis of 'CCN from Cloud Top' methods (Gettelman)
 - a. Global, regional and cases (Volcanoes)
 - b. Interested: Gettelman (CAM), Wang (CAM/WRF), Rosenfeld, Grosvenor (UM/UKESM)

Results during 2019–2020: Several cross comparisons and a case study were analyzed by different groups. There were several discussions between Leeds, Jerusalem, and Nanjing. This item goes a bit beyond natural laboratories. Methods are still being tested.

A detailed list of topics and work follows below.

Case Studies as a target:

- C1:** Lagrangian plume trajectory model applied to Kilauea and S. Sandwich Islands in satellite (HYSPLIT), LES, regional and global model
- C2:** Forecast/Hindcast of global emission changes due to SO₂ in 2020
- C3:** SE Atlantic shipping corridor
- C4:** Holuhraun eruption

Field projects to target? (ACRUISE)

Detailed list of Topics:

- 1. The AEROCOM-ACI GCM effort on volcanic emissions (Florent Malavelle)
 - a. Aerocom-ACI GCM experiment. Might consider some of these natural laboratories as part of it.
- 2. Regional/LES modelling of volcanic emissions

- a. (interested, Minghuai. Currently performs WRF-Chem simulation for the VOCALS field campaign, and would be happy to participate in this effort)
 - b. Possibly work with VOG model (Univ Hawaii, Gettelman contact Lacey Holland and Steven Businger, Univ Hawaii).
 - c. Set up and perform Lagrangian LES inside RCM - application to **C1** (Jan Kazil)
 - d. High-resolution 25 km CESM2 global output 1hourly data for selected regions (to compare to satellites section 3b; Andrew Gettelman).
 - e. Univ Leipzig does ~2 km resolution ICON simulations around Holuhraun, Eyjafjallajökull and Pinatubo within a German national project (<https://physik.uni-greifswald.de/ag-von-savigny/projects/dfg-research-unit-volimpact-for-2820/volcloud/>) (collaboration with Corinna Hoose @Karlsruhe) / **C4**
 - f. Oxford may be interested in joining using ICON-HAM in CRM mode
3. Satellite data analysis of recent effusive volcanic eruptions.
- a. Likely targets are Holuhraun (Iceland 2014-2015), Kilauea (2008 and 2018), and Ambrym (Vanuatu). Andrew Gettelman with Jennifer Griswold, Univ. Hawaii), possibly also MetOffice/Exeter. (Jim Haywood).
 - b. Lagrangian trajectory analysis of aerosol plumes and their interaction with clouds
 - i. Combine satellite cloud retrievals with ship plumes modeled using HYSPLIT and AIS data applied to case studies (Christensen; Gryspeerd) **C1/C2**.
 - ii. Domain-averaged indirect effect comparing upstream vs downstream from several satellites of passive degassing volcanoes (Adam Povey)
 - iii. Initial work linking AIS/ship emission estimates to shiptracks - preliminary results paper under review (Gryspeerd) - links to (i) but I didn't want to trample on it
 - iv. Analysis of large scale gradients in cloud properties induced by industrial and natural aerosol emissions (Velle Toll)
4. Detailed study quantifying cloud impacts along shipping corridors.
- a. Michael Diamond used Universal Kriging method to extract spatial patterns of affected cloud fields in satellite data. **C3**
 - i. Compare "bottom-up" estimates from AIS+HYSPLIT in SE Atlantic with "top-down" kriged estimate? (interested, Michael)
 - ii. Ideas for exploring different relationships in tropical (no clear response) versus subtropical domain?

- b. Regional modeling effort too? **C3** (interested, Minghuai, Michael, Anna)
 - i. Regional efforts are unlikely to be multi-year (run time limitations), so one should carefully choose a time period representative of the climatological conditions to facilitate model-satellite comparison (comment: Anna)
 - ii. Collaboration with ACRUISE modeling efforts?x
- 5. Forecast/Hindcast of the impact of new shipping SO2 emissions restrictions
 - a. Global runs: GCM remove SO2 from shipping emissions for an idealised perturbation study based on the expectations from the 2020 SO2 restrictions. **C2** (Andrew Gettelman). Also Watson-Parris with ECHAM-HAM
 - b. Detailed regional-scale HadGEM-UKCA modeling of the Atlantic basin with/without ship emissions and pre/post 2020 global International Maritime Organisation regulations on sulphur emissions (Ken Carslaw; ACRUISE - Leeds?). **C2**
 - c. Satellite observations of the pre/post 2020 event (Matt Christensen, Duncan Watson-Parris)
- 6. Applying Rosenfeld et al. (2019) approach to models and satellite observations: Can we use perfect model experiments to evaluate the mostly positive LWP adjustments and the very large cloud fraction adjustments retrieved using the Rosenfeld approach (E.g. compared to the relatively weak responses observed from the Holhuraun case study and ship/volcano track analysis from Toll et al. (2017)).
 - a. Danny had done some satellite work. **C4?**
 - b. Andrew and Danny (with Minghuai) are looking into what happens if you apply the methods to a GCM: instantaneous output, and a MODIS simulator even, 1° resolution. Could also be applied to Other GCMs. But would anyone believe a GCM? If it fails is it the GCM or the method **C?**
(Minghuai: the comparsion with different physical parameterization/models would help to reveal model differences and deficiencies; and hopefully to understand why, with process-level diagnostics. Models can also help to connect the cloud fraction/Nc relationship to radiative forcing).
A similar analysis is currently conducted for WRF-Chem for the VOCALS region (Minghuai)
 - c. Try the method in LES as well **C1/C2**